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Research Article

Comparative Analysis of Proximate Composition, Functional Properties and Vitamin A Content in Two OFSP Varieties (Umuspo3, Carrot C) and Cassava Starch

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Abstract

Comparative study of the proximate, functional and vitamin A content of two varieties of orange fleshed sweet potato (UMUSPO3 and Carrot C) and cassava starch was studied. Standard conventional method was used to produce the OFSP starch while commercial cassava starch was purchased and both were subjected to proximate, functional properties and vitamin A content analysis. The moisture, fat, protein, fiber, ash and carbohydrate results ranged from 6.05 to 9.10, 0.11 to 0.34, 0.25 to 0.45, 0.08 to 0.65, 0.31 to 0.51 and 89.73 to 92.16%; gelation temperature (60 to 65 0C), solubility (5.55 to 7.45%), swelling power (4.16 to 10 g/g), paste clarity (15.80 to 66.53%), amylose content (14.02 to 25.02%), syneresis (1.41 to 3.90%w/w), viscosity (6.22 to 7.34Cp), water absorption capacity (1.82 to 1.86g/ml), bulk density (0.44 to 0.64g/ml) and pro vitamin A (3.75 to 7.87mg/g). Notably, the ash (0.51%) and fiber (0.65%) content in OFSP starch is higher compare to cassava starch ash (0.31%) and fiber (0.08%) content. OFSP starch exhibited better higher solubility and swelling power when compared with the cassava starch due to the granule structure and molecular complex of its starch granules which have a semi-crystalline structure with looser molecular association allowing greater water uptake and solubility upon heating. Based on the result findings especially the functional properties and provitamin A, OFSP starch could be used as a superior complement to cassava starch in various food applications.

Keywords: OFSP Starch, Cassava Starch, Proximate Composition, Functional Properties and Vitamin A

Introduction

Starch is an essential biopolymer found abundantly in nature and is the main energy source for humans and animals. Starch serves as a ubiquitous raw material commonly utilized in the food industry because it is a dynamic ingredient whose performance hinges on its amylose (20-25%) and amylopectin (75-80%) ratio. Starch is a fundamental component in food systems, widely used for its functional roles in thickening, gelling, water retention, and texture modification. The ratio of amylose to amylopectin is a key determinant of the physicochemical characteristics of starch [1]. This ratio significantly impacts starch's digestibility, dispersibility, and rheological behavior—factors essential to its functionality in both food and industrial applications. Starches with high amylose content (AC) are typically more resistant to digestion and exhibit superior mechanical strength, making them highly suitable for the development of innovative starch-based materials [2]. The amylose forms firmer gels and contributes to resistant starch, while the amylopectin enhances viscosity, swelling, clarity, and film-forming properties. Starch is pivotal in modern food science in analytical and green processing techniques, which is expanding its functionality, sustainability, and health potential. Starches are being increasingly utilized in both food and non-food applications due to their affordability, wide availability, biodegradability, and neutral functional properties [3]. Starch plays a vital role in determining the texture of food products and is extensively utilized in both food and industrial applications as a thickening agent, colloidal stabilizer, gelling agent, bulking agent, and for water retention purposes [4]. In many countries, especially in Nigeria, cassava (*Manihot esculenta*) starch dominates due to its high yield, affordability, and neutral taste.

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However, orange-fleshed sweet potato (OFSP) starch is emerging as a nutritionally superior alternative, particularly because of its inherent provitamin A content and functional properties. Orange-fleshed sweet Potato (OFSP) varieties are rich in vitamin A and highly nutritious, although they contain relatively low dry matter content [5]. Beta-carotene, the primary source of vitamin A in OFSP, helps combat vitamin A deficiency [6]. In many developing countries, including Nigeria, vitamin A deficiency remains widespread and poses serious health risks, particularly for young children. According to Low *et al.,* consuming 100 grams of orange-fleshed sweet potato varieties containing approximately 3 mg of β-carotene per 100 grams (fresh weight) is sufficient to meet the recommended daily intake of vitamin A [7]. This regular intake can help prevent vitamin A deficiency in pregnant women and reduce the risk of blindness in children.

This comparative study evaluated the proximate composition, functional properties, and vitamin A content of starches from OFSP varieties UMUSPO3 and carrot C to cassava starch. The goal is to generate information based on experimental data to back up on their potential as complementary or superior alternatives in food formulations aimed at improving nutrition and food quality, especially in contexts affected by vitamin A deficiency.

Materials and Methods

Raw material sample source

The samples used in the study, Orange flesh sweet potato, UMUSOP3 OFSP was obtained from National Root Crops Research Institute, Umudike, Abia State, Carrot C was obtained from Zadok Farms limited, Yenegoa, Bayelsa State while edible starch was purchased from Eke-Awka market Awka, Anambra State, Nigeria.

OFSP starch production

The starch of the OFSP varieties were extracted and dried according to the method described by Price (2015) as shown in Fig.1.

A Statistical Analysis

The result was statistically analysed using SPSS (version 23.00) with one way analysis of variance (ANOVA). Significant difference between samples was tested at $p<0.05$ using Ducan multiple range test.

Results and Discussion

Proximate Composition of the OFSP Varieties and Cassava Starch

The Proximate composition of the OFSP varieties and cassava dried starch is presented in Table 1. There was significant ($P<0.05$) difference in moisture, fiber and carbohydrate content of the OFSP starch varieties when compared with cassava starch except in the protein, ash and fat content which was not significant ($P>0.05$). The fiber and carbohydrate of the OFSP starch was significantly ($P<0.05$) higher than that of cassava starch.

However, among the two varieties of OFSP analyzed, UMUSOP3 had a higher protein, ash, fiber and fat while carrot C was higher in carbohydrate content only. This could mean that based on this result finding, UMUSOP3 could be liked to be of better nutritional value when compared to carrot C.

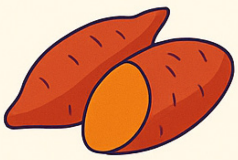
OFSP starch is more in fiber than cassava starch because its root is fiber-rich and its extraction processes are often less intensive, leaving residual fiber while cassava starch is heavily processed to remove fiber, so its fiber content is minimal. This means that OFSP starch is a superior choice when nutritional flours, prebiotic-rich foods or fiber-enhanced products is considered. Lower residual moisture of OFSP starch is due to the compact granule structure which retains less moisture. This is because OFSP granules often exhibit a more compact and crystalline structure which reduces their affinity for water, allowing them to dry more thoroughly [12].

Mohammad *et al.*, reported 1.17 to 4.33% ash, 1.91 to 5.83% protein, less than 1% fat, for OFSP flour while fiber (2.2%), fat

Table 1: Proximate composition of the OFSP varieties and cassava dried starch

Dried Samples	Moisture	Protein	Carbohydrate	Ash	Fiber	Fat
UMUSOP3	$7.04^{b}\pm0.02$	$0.35^{c}\pm0.04$	$91.20^{b}\pm0.10$	$0.51^{a}\pm0.04$	$0.65^{a}\pm0.02$	$0.25^{a}\pm0.3$
CARROT C	$6.05^{c}\pm0.05$	$0.25^{c}\pm0.02$	$92.16^{a}\pm0.06$	$0.34^{b}\pm0.02$	$0.64^{a}\pm0.02$	$0.11^{a}\pm0.02$
Cassava	$9.10^{a}\pm0.02$	$0.45^{c}\pm0.02$	$89.73^{c}\pm0.02$	$0.31^{b}\pm0.03$	$0.08^{b}\pm0.02$	$0.34^{a}\pm0.02$

Mean ± standard deviation. Mean followed by different superscript within the same column are significantly different ($p<0.05$).



Orange fleshed sweet potato roots

↓

Washing

↓

Peeling

↓

Grinding

↓

Sieving (using muslin cloth)

↓

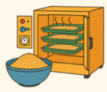
Extracting

↓

Dewatering

↓

Drying (600C for 4 hours using cabinet dryer)



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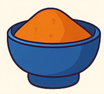
Milling



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Orange fleshed sweet potato Starch Powder

Fig. 1: Production of OFSP starch powder.

Source: Price (2015).

Proximate composition

The proximate composition was determined according to the method of AOAC while the carbohydrate was estimated by difference as described in Odoh, et al. [8,9].

Functional properties

Functional properties

The solubility, swelling power, paste clarity, viscosity, water absorption capacity and amylose content were all determined according to the standard methods as described by Onwuka 2018 while syneresis was done according to the method described by Guzman-Gonzalez et al. [10].

Vitamin content

The vitamin A content was determined according to the method of AOAC [11].

(0.28%), protein (2%) was reported by USDA (2018) for potato flour [13]. The result obtained for moisture (10 to 20%), ash (0.20 to 0.33%), protein (0.2 to 0.25%), fat (0.06 to 0,07%) by Soni *et al.* (1993) for sweet potato starch was above the moisture (6.05 to 7.04%), ash is within the same range (0.34 to 0.51%), protein is within close range (0.25 to 0.35%), fat is in close range (0.11 to 0.25%) with the obtained results from the study.

Functional Properties of OFSP Varieties and Cassava Starch

The Functional properties of OFSP varieties and cassava starch is seen in Table 2. Generally, there was significant ($P<0.05$) difference in all the OFSP starch functional parameters (gelation temperature, solubility, swelling power, paste clarity, amylose content, syneresis, water absorption capacity and bulk density) analyzed when compared with the cassava starch. The solubility, swelling power, amylose content and viscosity of the OFSP starch was significantly higher than that of cassava starch while the gelation temperature, paste clarity, syneresis, water absorption capacity and bulk density of cassava starch is significantly higher when compared to OFSP starch.
There was also a notable significant difference between the two varieties of OFSP analyzed in the functional properties. UMUSOP3 ranked higher in gelation temperature, paste clarity and viscosity while carrot C ranked higher in solubility, swelling power, amylose content, syneresis, water absorption capacity and bulk density.

The results from this study for water absorption capacity (1.82 to 1.84g/ml), paste clarity (15.80%), swelling power (7.90 to 10g/g) and solubility (7.26 to 7.45%) were higher than the values of the water absorption capacity (0.62 to 0.66ml/g), paste clarity (0.44-0.46), swelling power (3.01 to 4.30g/g at 50 and 600C) and solubility (0.77 to 6.35% at 50 to 90 0C) reported by Surendra Babu *et al.* [12].

The higher solubility and swelling power of the OFSP starch when compared with the cassava starch could be due to the granule structure and molecular complex of OFSP starch granules which have a semi-crystalline structure with looser molecular association allowing greater water uptake and solubility upon heating [14]. Phosphorylated starches generally swell more, OFSP contain similar bound phosphate to cassava enhancing swelling [14]. High swelling power of starch connote strong thickening, soft texture and high digestibility while low swelling power connotes firmer gels, elastic strands and enhanced resistant starch. Swelling power is a central functional attribute, understanding and manipulating swelling power through starch selection and formulation allows process control over texture, processing and nutritional outcomes.

The higher amylose content and viscosity of OFSP starch could be due to its inherit starch composition. The slightly higher amylose enhances viscosity and alters gelation/syneresis behavior [15]. The higher viscosity and bulk density of the OFSP when compared with cassava starch is due to its molecular structure, amylose-amylopectine balance and residual non-starch components while the bulk density could be attributed to differences in their granule morphology (smaller and more compact granules compared to cassava starch, allowing tighter packing), particle size and composition (higher in non-starch content such as residual proteins, lipids and dietary fiber than cassava starch). The more the amylose content the higher the solubility and high solubility enables minimal heating time, quick in digestion raising glycemic index. This explains why the OFSP starch was observed to be high in amylose, solubility compare to cassava starch.

Moorthy *et al.*, stated that fiber, lipids and protein in OFSP starch reduced clarity, water absorption capacity and influences gel strength and viscosity [16].

Lower gelation temperature of the OFSP starch when compared with cassava starch is due to the granules in OFSP starch which softens earlier due to its looser crystal structure and molecular composition.

Lower paste clarity of the OFSP starch when compared to cassava starch could be due to OFSP starch paste often appears less clear due to higher leached fiber, protein and lipid residue which scatters light.

OFSP starch exhibited reduced syneresis, due to its branched amylopectin which limits recrystallization compare to cassava starch while the lower water absorption capacity is due to the reducing sugars and structural changes through endogenous enzymes limiting water binding [17]. OFSP starch granules are larger, less dense, structurally looser, promoting swelling, early gelatinization, lower packing density [18].

Mean ± standard deviation. Mean followed by different superscript within the same column are significantly different ($p<0.05$).

GT- Gelation Temperature, Sol.- Solubility, SP- Swelling Power, PC – Paste Clarity, AC – Amylose Content, SYN – Syneresis, WAC – Water absorption capacity, BD – Bulk Density.

Vitamin A Content of Dried Starch of OFSP Varieties and Cassava

Table 3 shows the vitamin A content of dried starch of OFSP varieties and cassava. It was observed that the carrot C ranked the highest value (7.87 mg/g), followed by UMUSOP3 (4.90mg/g) and cassava starch (3.75mg/g). This is because white cassava flour has negligible provitamin A (89ug/mg) while OFSP is rich in beta-carotene (>1000ug/100g) [19]. With the exception of biofortified yellow cassava variety but typically cassava starch lacks it unless a special breed. OFSP starch powder retains substantial provitamin A even after drying and cooking making it effective for dietary intervention while cassava processing further reduces any trace of carotenoids if present. The provitamin A in the OFSP starch varieties ranged from 4.9 to 7.87mg/g which is within the range reported by Olatunde *et al.* (2020) for OFSP carotenoid content (1.8 to 12mg/100g) but lower compare to the reported value of 9.19mg/100g for UMUSOP3 by Gamaliel and Joseph [20].

Conclusion

Despite the fact that cassava starch is renowned for its excellent functional properties including high peak viscosity and stability, making it ideal for various food applications like sauces and baked goods while OFSP-Starch on the other hand, exhibits lower gelation temperature, paste clarity, syneresis, water absorption capacity. However, incorporating OFSP starch into food systems would not only enhances the micronutrients but also could be used as a superior complement to cassava starch in various food applications.

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Declaration of conflict of interest

The authors declare no conflict of interest.

Table 2: Functional properties of OFSP varieties and cassava starch

Starch sample	GT (0C)	Sol. (%)	SP (g/g)	PC (%)	AC (%)	SYN (%w/w)	Viscosity (Cp)	WAC (g/ml)	BD (g/ml)
UMUSOP3 OFSP	61.00^{b}±0.0	7.26^{b}±0.4	7.90^{b}±0.1	18.30^{b}±0.0	24.58^{b}±0.1	1.16^{c}±0.1	7.34^{a}±0.0	1.82^{c}±0.1	0.44^{c}±0.0
Carrot C OFSP	60.00^{c}±0.0	7.45^{a}±0.5	10.00^{a}±0.1	15.80^{c}±0.0	25.02^{a}±0.3	1.41^{b}±0.0	7.08^{b}±0.4	1.84^{b}±0.0	0.64^{a}±0.0
Cassava	65.00^{a}±0.0	5.55^{c}±0.1	4.16^{c}±0.2	66.53^{a}±0.1	14.02^{c}±0.3	3.90^{a}±0.1	6.22^{c}±0.3	1.86^{a}±0.0	0.56^{b}±0.0

Mean ± standard deviation. Mean followed by different superscript within the same column are significantly different ($p<0.05$).

Table 3: Vitamin A content of dried starch of OFSP varieties and cassava

Starch sample	Vitamin A (mg/g)
UMUSOP3 OFSP	4.90^{b}±0.01
Carrot C OFSP	7.87^{a}±0.01
Cassava	3.75^{c}±0.02

Mean ± standard deviation. Mean followed by different superscript within the same column are significantly different ($p<0.05$).

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